

ON THE HEMIPENES OF THE SAURIA.

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In the course of preparation of a work on the scaled reptiles of North America for the Smithsonian Institution, it has become necessary to examine some neglected parts of the anatomy. This I have recently done for the hemipenes of the Ophidia, with results of considerable importance to the systematic indications.¹ In the present paper I give the results of a similar investigation into the corresponding part of the anatomy of the lizards. Very little attention has been given to the subject hitherto, and our knowledge up to 1856² is thus summarized by Stannius: "A duplication or bifurcation of each organ is present in *Lacerta* and in *Platydictylus guttatus*. The copulatory organs of the Chamæleonidæ are distinguished by their shortness. In various Varanidæ which have been investigated the internal cavity (external when protruded) has transverse concentric folds. A fissure interrupts these folds so that they are not complete annuli. The extremity is acuminate and expands at the base, forming a kind of glans."

In 1870³ J. E. Gray describes and figures this organ of *Varanus heraldicus*, giving the best illustration that I know of. Besides these references I know of nothing later.

As was to have been anticipated, I have found these organs to correspond with the rest of the structure, and to furnish invaluable aids to the determination of affinities among the Sauria. Reference to them cannot be omitted henceforth in cases where the other characters render the question of affinity uncertain.

In the Sauria the male intromittent organ or hemipenis, presents much variety of structure, showing some parallels to the corresponding part in the snakes. It is, however, rarely spinous, as is so generally the case in the Ophidia, the only spinous forms being, so far as I have examined, the American Diploglossinæ and genera allied to *Cophias*. The higher Sauria have the apical parts modified as

¹ Transactions of the American Philosophical Society, 1895, p. 187.

² Zootomie der Amphibien, p. 266.

³ Annals Magaz. Nat. History, 1870, VII, p. 283.

in the Ophidia, by the presence of calyculi. Such are characteristic of the Rhiptoglossa and Pachyglossa. The Nyctisaura possess the same feature. The Diploglossa, Helodermatoidea and Thecaglossa have the organ flounced, the flounces often pocketed or repand on the margin. In the Leptoglossa we have laminae only; in the Tiidæ mostly transverse, and in the Scincidae mostly longitudinal. In various genera terminal papillæ are present. The organ may be simple or bifurcate or merely bilobate. I have not met with the case so common in Ophidia, where the sulcus spermaticus is bifurcate and the organ undivided.

The structures of the hemipenis have a constant systematic value. As in the Ophidia, the value differs with the character, but it varies from generic to superfamily in rank.

In the Chamaeleonidæ the greater part of the surface of the hemipenis is coarsely calyculate, generally in a transverse direction. There are remarkable papillæ at the apex, which differ in the different forms. In *C. pardalis* there is a kind of membranous apron proximad of the papillæ which presents an apex proximad opposite to the sulcus spermaticus. In *C. vulgaris* and *C. gracilis* the papillæ are erect, laminiform and transverse and serrate on the edges. The principal pair have a few papillæ in front of and behind them, and in *C. gracilis* there is, behind these, on each side, an oval body which is composed of three serrate laminæ packed obliquely together. In *C. gracilis* the proximal laminæ are low and have a margin of acute tubercles, and each serves as a collar to a much larger papilla. The latter is largely free and tongue-shaped, with the apex proximad, and its flat external surface is covered with three or four rows of conic papillæ.

I have had the opportunity of examining the hemipenis of a relatively small number of species of the Agamidæ; the surface is generally calyculate. I have not found terminal papillæ in the genera *Uromastix*, *Agama*, *Liolepis*, *Physignathus* or *Calotes*. The general construction is, that opposite the sulcus spermaticus is a strong longitudinal welt. Near the apex this welt becomes adherent to the side on which the sulcus runs, dividing the organ into two apical portions. The sulcus bifurcates and passes along the base of this partition. In *Liolepis* there are two welts enclosing a smooth space between them. In *Calotes cristatellus* there is a lesser welt on each side of the principal one. In all the genera the basal part is smooth, and it is sometimes thrown into longitudinal folds.

I have examined the hemipenis in thirty species of the Iguanidæ of the following genera: *Anolis*, *Xiphocercus*, *Polychrus*, *Basiliscus*, *Ctenosaura*, *Cyclura*, *Iguana*, *Corythophanes*, *Sauromalus*, *Crotaphytus*, *Dipsosaurus*, *Sceloporus*, *Callisaurus*, *Holbrookia*, *Enyalioides*, *Doryphorus*, *Microlophus*, *Uraniscodon* and *Phrynosoma*. These differ in the bifurcation of the organ, varying from undivided (*Cyclura*, *Iguana*) to deeply bifurcate (*Anolis*, *Doryphorus*, *Microlophus*, *Uraniscodon*). Other differences are seen in the number of welts and their surface structure, and the distribution and size of the calyces. Thus the calyces extend to the base in *Anolis*, but are confined to the apex in *Crotaphytus*. They exist in series only in *Cyclura*, *Iguana*, *Ctenosaura*, *Corythophanes* and *Sauromalus*. They cover most of the organ in *Sceloporus* and *Phrynosoma*. The systematic arrangement of the genera in accordance with the characters is as follows:

I. Calyces always present.

A. Three welts, one opposite the sulcus spermaticus and one parallel on each side of it transversely laminate: CTENOSAURA, CYCLURA, IGUANA, CORYTHOPHANES, SAUROMALUS, CROTAPHYTUS.

B. Three welts; one opposite sulcus, the others on each side of sulcus converging to median welt, and enclosing spaces with it; surfaces calyculate.

≈ Median welt confluent proximad: DIPSOSAURUS, LIOCEPHALUS, PHRYNOSOMA.

≈ ≈ Median welt projecting free proximad: CALLISAURUS, HOLBROOKIA.

C. No median welt; lateral welt from sulcus: SCELOPORUS.

D. A median, no lateral welts; calyculate.

≈ Not bifurcate; welt wide: ENYALIOIDES (calyces coarse).

≈ ≈ Bifurcate; welt long and narrow: ANOLIS (calyces minute).

E. No welts.

≈ Deeply bifurcate; calyces confined to branches: MICROLOPHUS, URANISCODON, DORYPHORUS.

≈ ≈ Shortly bifurcate; calyces extending proximad of branches: BASILISCUS.

II. No calyces or welts.

≈ Bifurcate; surface coarsely wrinkled: POLYCHRUS.

In the genera *Ctenosaura*, *Cyclura*, *Iguana*, *Sauromalus* and *Enyalioides* (*laticeps*) the organ is entire; in the others it is bilobate or bifurcate.

Of the *Nyctisauræ* I have examined the hemipenis in the genera *Thecadactylus*, *Platydictylus*, *Phyllodactylus* and *Gymnodactylus*. In these this organ is short and wide, appropriately to the fragility of the tail. It is also more or less deeply divided into two branches. The entire surface is calyculate, generally minutely so. In *Thecadactylus* each fork has three strong welts. In *Platydictylus* there is a welt opposite the sulcus which is very large in *P. aegyptiacus*, and divides, sending a half into each branch. In *Gymnodactylus pulchellus* the welts are not so heavy, below the bifurcation is a welt which encloses a circular area which is incomplete proximad. In *Eublepharis* the hemipenis is closely similar to that of the *Geconidæ*. It is short and deeply bifurcate; it has a single prominent welt. The surface of this is smooth, but the remainder of the surface is calyculate.

Of the *Zonuridæ* I have only seen the hemipenis of *Z. cordylus*. It is short and swollen, so that the spiral structure is accentuated; there is a rigid welt opposite the sulcus, which leaves a triangular space at one side proximad, which is finely calyculate. On the opposite side of the welt distad, is a wide space with radiating laminae from a smooth center. The presence of calyculi noted is exceptional in the *Diploglossa*, and indicates approximation to the *Pachyglossa* as far as it goes.

In the *Anguidæ* the hemipenis presents well marked characters, which distinguish the genera and perhaps the subfamilies. In *Celestus* the extremity carries an osseous spicule of relatively large size. Distad of the flounces are more (*C. stenurus*) or less (*C. badius*) numerous longitudinal series of recurved osseous spines which are longer near the sulcus spermaticus. In *C. stenurus* the flounces are apiculate at regular intervals; organ undivided. In the *Gerrhonotinæ* the flounces are cupped and continue to the apex without spines; in *Barissia* and *Gerrhonotus* the organ is bifurcate, in *Elgaria* simple. In *Anguis* a welt on each side of the sulcus has tubercular cross-ridges, and the remainder of the surface is marked with oblique folds with tubercular margins forming a chevron which is directed distad. In *Pseudopus apus* the organ is not symmetrical. Opposite the sulcus is a low, broad, smooth welt, and on each side the sulcus is margined by a thin welt or lip. This is

coarsely plicate transversely, the plicae extending to the welt. On the other side, the transverse plicae terminate at a band of fine longitudinal folds. In *Ophisaurus* the organ is undivided, and there is a welt with one edge and the proximal end free. It is covered with robust papillæ.

In Xantusiidae the hemipenis is bifurcate and is shortened as in many Geconidae, appropriately to the fragile tail. There is a welt on each side of the sulcus spermaticus which follows a short spiral direction. Opposite to the sulcus are two short, thick welts, which have the direction of parts of consecutive threads of a screw. All of the welts are deeply cross-folded.

In the Tiidæ two types may be observed of the structure of the hemipenis, but I have not had access to sufficient material to enable me to refer all the genera to the one or the other. In the typical members, as in the genera *Dracaena*, *Tupinambis*, *Amiva* and *Cnemidophorus*, the pattern consists of numerous delicate, imbricate, transverse laminae which are closely applied to each other. Opposite the sulcus all the genera display a welt, which has free borders. These are entire in *Dracaena* and pectinate in *Amiva* and *Cnemidophorus*; between these and the borders of the sulcus is a rounded welt on each side. The laminae are sublongitudinal, diverging proximad from the sulcus; on the first welt they turn sharply distad; between this and the welt they make a second chevron distad, turning proximad. Proximad of the median welt these laminae meet, forming a curve or chevron turned proximad. In *Cnemidophorus* there is one less chevron. In this genus and *Amiva* there is a strong, fleshy papilla at the apex of each tract between the welt and sulcus.

A modification is seen in *Centropyx (pelviceps)*. Here there is a narrow welt opposite the sulcus; on each side of the sulcus a prominent welt diverges from it proximad and approaches the proximal end of the median welt, so as to enclose a space with it. It is transversely plicate and the enclosed space on each side the median welt has the delicate transverse lamination characteristic of the Tiidæ. What is entirely peculiar is the presence at the apex of each of the laminate spaces of a large patch of acute flexible papillæ.

The plan is the same in *Anadia bogotensis*, but the details are different. The organ is bifurcate. A strong welt opposite the sulcus is divided into fine longitudinal folds, which are crimped transversely. The space between this and the sulcus is marked with

folds which diverge distad from the welt and become longitudinal, and are transversely crimped. In the longitudinal direction of the plicæ this genus differs from the *Tiidae*, and it is likely that *Ecpleopus* and other allied genera are similar.

In a third type represented by *Heteroclonium bicolor*,⁴ a welt bounds the sulcus on each side. The space between these is marked by a few feeble cross folds, and the borders support a single series of closely placed recurved spines. Genera allied to *Cophias* are likely to present this structure.

Of the *Lacertidae* I have examined the hemipenis in the genera *Lacerta*, *Acanthodactylus* and *Latastia*. They are bifurcate and bilobate. In each division and proximad to it is an oval area with transverse laminae surrounded by a welt. In *Acanthodactylus* one of the areas is marked by longitudinal folds.

Among the *Gerrhosauridae*, the hemipenis of *Gerrhosaurus nigrolineatus* has on its distad third, three welts opposite the sulcus, the median larger, all finely cross folded. Between one of these and the sulcus is a tract of coarse papillæ; between the other and the sulcus the surface is smooth.

Of the *Scincidae* I have examined the hemipenis in *Trachysaurus*, *Lepidothyris* (*fernandii*), *Euprepis* (*carinatus*), *Eumeces* and *Mabuia*. They are smooth and with more or less numerous longitudinal folds, excepting in *Trachysaurus*. Here the laminae diverge from the sulcus proximad and turn to a horizontal direction, meeting opposite the sulcus in a chevron directed distad. In *Euprepis carinatus* and *Eumeces obsoletus* some of the plicæ are cross-ribbed. In *Lepidothyris fernandii* the organ is shortly bifurcate, and each division has a membranous welt next the adjacent division.

In the *Anniellidae* the genus *Anniella* has the entire surface from one side of the sulcus to the other, thrown into transverse folds or

⁴ *HETEROCLONIUM BICOLOR* gen. et. sp. nov.

Char. gen. Frontonasal plates separating nasals; prefrontals and frontoparietals absent; nostril in suture between nasal and first labial plate; no interparietal. Limbs rudimental, two pairs; digits 4-1, the anterior clawed. No femoral pores. Different from *Sesquipes* (type *Cophias heteropus* Licht. Blgr.) which has the digits 4-2; and *Microdactylus* when they are 3-3. *Char. specif.* Scales in annuli of 28 scales, which are angular at the extremities, and alternate with those of the adjacent rows. Labials 5-6; temporals 2-2-2. Three large pre-anal plates, longer than wide. Tail long obtuse, hind legs minute. Anterior digits short, subequal. Brown above, separated abruptly on each side from the darker brown of the sides and lower surfaces. Chin and throat yellowish. Scales of upper surface each with a bluish spot. Total length 130 mm., length to vent 78 mm. Bogota; Philadelphia Museum Coll. Two specimens.

flounces, which are so wrinkled as to be more or less pocketed, much as in *Gerrhonotus (Elgaria)*. Organ undivided.

Of the Amphisbaenidae the only species of which I have obtained a satisfactory hemipenis is the African *Monopeltis galeatus* Hallow. The organ is bifurcate; each branch is marked with fine, close, transverse folds, while the region proximad of these has coarser folds directed transversely and obliquely.